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REPORT

on the PhD thesis presented by RUSLAN LEONIDOVICH LAPIN titled

CALCULATION OF ELASTIC AND STRENGTH CHARACTERISTICS OF MATERIALS WITH CRACKS

submitted for the Candidate of Science degree in specialization 01.02.04 - Solid Mechanics

Many industrial applications require knowledge about the mechanical and other properties of the material, taking into account its structure. Heterogeneities, inclusions of other materials, pores and cracks make this problem quite difficult. One possibility to solve such problems is the use of homogenization techniques. As usual, such techniques allow the overall description of the material behavior, but singular effects, as crack initiation, cannot presented by such models.

Analytical methods have several limitations when applied to current problem. In particular, for problems related to materials with cracks, it is possible to consider only simple crack geometries and paths. As usual, interaction of cracks cannot presented in a proper manner. In addition, fracture processes associated with special conditions (for example, hydrostatic pressure) are difficult to repeat experimentally due to scale factors.

In geomechanics the fracture can reach hundreds of meters and the influence of inhomogeneities not exceed several meters. To model such effects numerically, for example by finite elements, one needs very fine meshes and the computational costs are increasing dramatically. In addition, it is not so easy to realize suitable experiments. There is a demand concerning virtual experiments.

The boundary element method has with respect to the computational costs some advantages, but there are also limitations. The boundary element method is based on the establishment of the Green's function, which is for structures without inhomogeneities sometimes is not easy. Green's function of a layered medium as usual cannot be established analytically, but numerically. The thesis is devoted to the last one problem. It is considered the effect of cracks on the elastic and strength properties. The influence of the interaction of cracks and bridges between the crack faces on the effective elastic properties of the material is investigated. The

effect of the orientation of the crack, type of loading and layering of the medium on the strength properties is also presented. In the framework of the thesis, various methods are used (Finite element method, Boundary element method, Particle dynamics method) for solving problems. In addition, the results are compared.

Mr. Lapin formulates the scientific novelty of his thesis as follows:

1. A series of problems on the elastic deformation of a two-dimensional material with many randomly located cracks has been solved with the boundary element method.
2. The problem of the effect of bridges between the faces of an infinite crack on its normal and shear compliance is solved with the finite element method.
3. The problem of quasistatic deformation and fracture of a sample containing a single crack under various types of loading is solved with the particle dynamics method.
4. The problem of quasistatic crack growth in a three-layer medium is solved with the particle dynamics method.

All this four items are investigated in detail in the thesis. A special focus was made on the investigation of the accuracy, on the formulation of limitations of the given methods, and finally the results were compared to known solution in the literature.

The thesis is presented on a high scientific level using the direct tensor calculus. The literature survey is excellent, but the list of references contains several mistakes. The examples illustrating the theoretical part in a proper manner. There are no critical remarks.

Despite the above-mentioned remarks, the thesis deserves to be positive evaluated.

The thesis of R.L. Lapin “Calculation of Elastic and Strength Characteristics of Materials with Cracks” fulfills the requirements established by the decree “On Order of Granting Degrees in St. Petersburg State University”. Ruslan Leonidovich Lapin deserves to be granted with the Degree of Candidate of Physico-mathematical Sciences (Specialization 01.02.04 – Solid Mechanics).

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